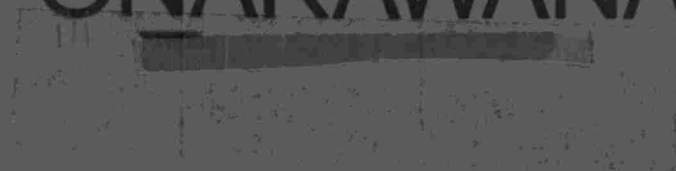


SOILS AND RELATED DEVELOPMENT PROBLEMS FOR THE PROPOSED STRIP-MINING OPERATION AT ONAKAWANA



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WORKING PAPER #1

Soils and Related Development Problems
for the Proposed Strip-Mining Operation
at Onakawana

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for

TASK FORCE ONAKAWANA

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1.0 BACKGROUND

The following investigation was undertaken to provide information on the soils of the Onakawana area to Task Force Onakawana. Emphasis was directed toward development problems that could arise from strip-mining in the area and, in particular, the consultants were instructed to pay specific attention to those problems concerned with erosion, disposal of waste products, slope stability and site reclamation.

A copy of the initial proposal is contained in Appendix A.

Although the geology of the site is being studied by other specialists, a section is included in this report, since it is closely interrelated with the soils and development problems discussed in the following sections.

2.0 INVENTORY DATA

2.1 Climate

The climate of Northern Ontario may be classified as modified continental with the modification being due to the presence of the Great Lakes on the south and Hudson Bay on the north. As a consequence spring comes late in comparison to a similar latitude in the Prairie Provinces. A pattern of relatively low winter and high summer precipitation prevails. Cold polar air masses producing dry clear weather persist in the area a greater portion of the time than in Southern Ontario, especially in the winter. In summer a continuing succession of cyclonic storms sweep over the area and warm, humid air masses of the south alternate with cooler and drier air from the north to give two or three days of fine weather

followed by warmer, more humid weather, often with a day or two of changeable winds and rain.

According to Chapman and Thomas (1968), Moosonee lies in the Albany climatic region and Cochrane lies in the Northern Clay Belt climatic region with the regional border being an east-west line approximately midway between these two communities. The lignite field lies in the southern portion of the Albany region. Climatic data for the towns of Moosonee, Cochrane, Smoky Falls and Abitibi Canyon are summarized in Table 1. Based on extrapolation of this information the Onakawana area can be said to have approximately the following climate.

- i) mean annual precipitation: 31 inches
- ii) mean precipitation (May-October): 19 inches
- iii) mean annual snowfall: 100-110 inches
- iv) length of growing season: 140-145 days
- v) mean annual frost free period: about 80 days
- vi) degree days ⁽¹⁾ (>42°F): 1750-1850

2.2 Geology

Any geological assessment of the environment must be based on a knowledge of the bedrock, surficial deposits, landscape and drainage pattern. These are dealt with below.

2.21 Bedrock

Except for a few small, isolated outcrops along river courses, the bedrock of the Onakawana region is obscured by glacial and post-glacial deposits. Direct knowledge of the solid geology comes principally from the extensive drilling programme of the Ontario Department of Mines.

- (1) Degree-day: The algebraic sum of the differences between the mean temperature of each day and 42°.

Table 1. Summary of Climatic Data for Abitibi Canyon, Cochrane, Moosonee and Smoky Falls*

3.

ELEMENT and STATION	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEPT	OCT	NOV	DEC	YEAR	2
ABITIBI CANYON														
LATITUDE 49 53 N LONGITUDE 81 34 W ELEVATION 670 FT ASL														
MEAN DAILY TEMPERATURE (DEG F)	-3.0	0.9	11.9	30.0	44.5	56.8	62.2	59.8	50.5	39.2	22.3	5.0	31.7	2
MEAN DAILY MAXIMUM TEMPERATURE	10.0	14.5	25.6	41.8	56.3	69.2	74.2	71.2	60.4	47.6	29.5	15.0	42.9	2
MEAN DAILY MINIMUM TEMPERATURE	-15.9	-12.8	-1.8	18.2	32.6	44.6	50.2	48.4	40.6	30.8	15.1	-5.0	20.4	2
MAXIMUM TEMPERATURE	45	52	66	84	91	95	101	97	101	80	66	49	101	3
MINIMUM TEMPERATURE	-54	-57	-43	-29	10	23	31	30	20	1	-37	-46	-57	3
MEAN RAINFALL (INCHES)	0.03	0.03	0.19	0.86	2.58	3.51	3.70	3.46	3.69	2.38	1.03	0.08	21.51	1
MEAN SNOWFALL	12.9	9.1	11.3	8.2	1.8	0.0	0.0	0.0	0.2	3.8	14.1	11.0	72.4	1
MEAN TOTAL PRECIPITATION	1.32	0.91	1.32	1.68	2.76	3.51	3.70	3.46	3.71	2.76	2.44	1.19	28.75	1
NO.OF DAYS WITH MEASURABLE RAIN	8	8	1	4	11	13	14	12	16	11	4	1	87	1
NO.OF DAYS WITH MEASURABLE SNOW	11	11	7	4	1	*	*	*	*	2	11	13	60	1
NO.OF DAYS WITH MEAS PRECIPITATION	11	11	8	8	12	13	14	12	16	12	14	14	145	1
MAXIMUM PRECIPITATION IN 24 HRS	0.75	0.75	1.25	1.30	2.00	2.83	1.75	4.33	2.15	1.74	1.90	0.86	4.33	1
COCHRANE														
LATITUDE 49 04 N LONGITUDE 81 02 W ELEVATION 902 FT ASL														
MEAN DAILY TEMPERATURE (DEG F)	1.2	4.8	15.7	32.9	46.6	58.0	62.9	60.8	51.5	40.5	23.9	7.7	33.9	1
MEAN DAILY MAXIMUM TEMPERATURE	12.1	15.7	26.8	43.5	58.5	70.1	74.6	72.1	61.4	48.9	30.8	16.7	44.3	1
MEAN DAILY MINIMUM TEMPERATURE	-9.7	-6.2	4.5	22.3	34.7	45.8	51.1	49.4	41.5	32.1	17.0	-1.3	23.4	1
MAXIMUM TEMPERATURE	45	53	68	85	92	98	99	97	95	84	69	52	99	5
MINIMUM TEMPERATURE	-50	-50	-39	-22	10	20	31	28	19	5	-37	-43	-50	5
MEAN RAINFALL (INCHES)	0.07	0.06	0.36	1.26	2.59	3.50	3.97	3.20	3.55	2.26	1.12	0.34	22.28	1
MEAN SNOWFALL	19.7	16.0	15.8	8.5	1.9	1	0.0	0.0	0.9	4.0	19.0	21.4	107.2	1
MEAN TOTAL PRECIPITATION	2.04	1.66	1.94	2.11	2.78	3.50	3.97	3.20	3.64	2.66	3.02	2.48	33.00	1
NO.OF DAYS WITH MEASURABLE RAIN	1	1	2	6	11	12	13	13	14	10	6	2	91	1
NO.OF DAYS WITH MEASURABLE SNOW	13	13	10	5	2	*	*	*	1	3	11	16	74	1
NO.OF DAYS WITH MEAS PRECIPITATION	14	14	11	10	12	12	13	13	14	12	16	18	159	1
MAXIMUM PRECIPITATION IN 24 HRS	1.68	1.04	1.40	1.90	1.50	2.82	2.72	2.22	2.74	1.53	2.47	1.04	2.82	1
MOOSONEE														
LATITUDE 51 16 N LONGITUDE 80 39 W ELEVATION 34 FT ASL														
MEAN DAILY TEMPERATURE (DEG F)	-5.1	-0.4	10.5	27.5	41.3	53.5	60.1	58.8	50.1	39.0	22.2	4.2	30.1	1
MEAN DAILY MAXIMUM TEMPERATURE	5.4	11.3	22.2	37.3	51.0	64.4	71.3	69.1	59.2	46.4	28.7	13.3	40.0	1
MEAN DAILY MINIMUM TEMPERATURE	-15.6	-12.0	-1.2	17.6	31.5	42.5	48.8	48.4	40.9	31.6	15.7	-4.9	20.3	1
MAXIMUM TEMPERATURE	45	51	60	80	92	94	96	95	89	80	66	51	96	3
MINIMUM TEMPERATURE	-52	-50	-43	-25	1	21	29	30	21	2	-30	-44	-52	3
MEAN RAINFALL (INCHES)	0.07	0.06	0.27	0.73	2.41	3.40	3.14	3.20	3.22	2.17	0.89	0.23	19.99	1
MEAN SNOWFALL	18.0	17.8	13.7	10.0	4.4	0.3	0.0	0.0	0.1	6.9	19.3	19.8	110.3	1
MEAN TOTAL PRECIPITATION	1.87	1.84	1.64	1.73	2.85	3.63	3.14	3.20	3.23	2.86	2.82	2.21	31.02	1
NO.OF DAYS WITH MEASURABLE RAIN	8	8	2	5	12	14	16	15	17	12	5	2	100	1
NO.OF DAYS WITH MEASURABLE SNOW	17	15	12	9	5	1	*	*	*	5	15	19	93	1
NO.OF DAYS WITH MEAS PRECIPITATION	17	15	13	13	15	15	16	15	17	15	19	20	190	1
MAXIMUM PRECIPITATION IN 24 HRS	1.24	1.10	1.14	1.38	1.46	2.12	2.32	1.53	2.36	1.30	1.57	0.82	2.36	1
SMOKY FALLS														
LATITUDE 50 04 N LONGITUDE 82 10 W ELEVATION 780 FT ASL														
MEAN DAILY TEMPERATURE (DEG F)	-3.5	0.4	11.8	29.7	44.6	57.1	63.4	60.7	50.6	39.3	21.8	4.8	31.7	1
MEAN DAILY MAXIMUM TEMPERATURE	8.4	13.6	25.1	40.9	55.3	68.0	73.8	70.7	59.5	47.3	29.0	14.8	42.2	1
MEAN DAILY MINIMUM TEMPERATURE	-15.4	-12.8	-1.5	18.4	33.6	46.2	53.0	50.7	41.7	31.3	14.5	-5.2	21.2	1
MAXIMUM TEMPERATURE	48	51	67	84	90	94	100	94	92	80	67	55	100	3
MINIMUM TEMPERATURE	-53	-48	-42	-26	4	23	35	32	24	4	-31	-42	-53	3
MEAN RAINFALL (INCHES)	0.03	0.08	0.18	0.35	2.46	3.20	3.07	2.82	3.01	2.23	0.84	0.06	18.63	1
MEAN SNOWFALL	24.2	21.0	16.7	9.7	2.8	1	0.0	0.0	0.5	5.6	24.3	24.6	129.4	1
MEAN TOTAL PRECIPITATION	2.45	2.18	1.65	1.82	2.74	3.20	3.07	2.82	3.06	2.79	3.27	2.52	31.57	1
NO.OF DAYS WITH MEASURABLE RAIN	8	8	1	5	11	13	14	12	15	11	4	1	87	1
NO.OF DAYS WITH MEASURABLE SNOW	15	13	9	5	2	*	*	*	1	4	14	17	80	1
NO.OF DAYS WITH MEAS PRECIPITATION	15	13	10	9	12	13	14	12	15	13	16	17	159	1
MAXIMUM PRECIPITATION IN 24 HRS	1.25	0.90	1.40	1.10	1.95	3.40	2.06	1.88	2.28	1.70	1.50	1.45	3.40	1

*after "Temperature and precipitation tables for Ontario", Vol. IV, (1967). Canada Department of Transport.

TABLE 2. Bedrock Sequence from Onakawana Drill Hole A.

Surficial deposits (6 feet of muskeg, 72 feet of Pleistocene-
See Table 3).

	UNCONFORMITY
LOWER CRETACEOUS	Predominantly fireclay 43 ft. thick. LIGNITE 23 ft. bed Fireclays and sand, minor lignite - 27 feet. LIGNITE 21 ft. bed. Dark to light coloured fireclays with minor lignite 56 feet.
	UNCONFORMITY
DEVONIAN	Shales, clays and sandstones, with some calcareous rocks in Middle and Lower Devonian. Some shales are bituminous and pyritiferous. Gypsum occurs. Total thickness 777 ft.
	LARGE UNCONFORMITY
	PRECAMBRIAN PLUTONIC ROCKS (at depth of 1,027 ft.)

Source: Dyer and Crozier, (1933); Martison, (1952).

TABLE 3. Typical Quaternary Sequence for Onakawana Region.

		AGE
RECENT	Muskeg and Swamp deposits away from river courses. Fluviatile silts and gravels along rivers.	4000 y.
	Tyrrell Sea deposits, silt and silty clay	7000 y.
UNCONFORMITY		
PLEISTOCENE	Upper drift: till, silt, clay and sand. Few boulders and pebbles, mostly calcareous.	10,000 y.
	(Climax of Wisconsin Glaciation)	18,000 - 20,000 y.
UNCONFORMITY		
	Missinaibi interglacial deposits, silt and clay predominantly, contains peat and plant remains.	>53,000
UNCONFORMITY		
	Middle drift: gravel, silt, sand and clay (some vared). Limestone pebbles predominate; some Precambrian lithologies.	?
UNCONFORMITY		
	Lower Drift: hard dense till.	?
	(Beginning of Quaternary to nearest m.y.)	1,000,000
LARGE UNCONFORMITY		
CRETACEOUS BEDROCK		

Sources: Lee (1968), Terasmae and Hughes (1960).

The oldest rocks proven by drilling are Precambrian gneisses, granites and syenites that, at Onakawana, lie at a depth of 1027 feet. There is evidence that the rocks underwent weathering before an extensive erosional interval levelled them down to a peneplain-like surface that was ultimately invaded by Paleozoic seas. This marine episode produced Ordovician and Silurian rocks elsewhere around Hudson Bay but at Onakawana they are absent. It is possible that they were never deposited there or if they were deposited they were eroded away in an interval of continental conditions after the Silurian Period. This interval was followed by a second marine transgression that laid down the Middle and Upper Devonian rocks that overlie the Precambrian at Onakawana. A gradual change to terrestrial conditions again produced a continental margin environment by Lower Cretaceous time and in this environment, probably in brackish-water swamps, there was deposition of the lignite that constitutes the principal geological potential in the area.

The Lower Cretaceous rocks are truncated by an erosional surface overlain by unconsolidated deposits, has an irregular topography shown on the Glacial Till Isopach map prepared by Master Explorations Ltd. The average depth to bedrock is roughly 70 feet. (2)

2.22 Surficial deposits

The weathered Cretaceous rocks were eventually covered by Pleistocene ice that left at least three till sheets in the region, with the upper two separated by interglacial deposits, marking a warm climatic

(2) For a fuller account of the geological history of the area refer to Sanford and Norris (1970).

period between ice advances. The superincumbent load of ice depressed the land surface to below sea level so that when the ice finally disappeared, about 7000-8000 years ago, an arm of the sea invaded the area producing an early and more extensive form of Hudson Bay: in older reports this is referred to as the Champlain Sea, though recently the name Tyrrell Sea has been adopted. This body of water deposited marine clays and silts which have since been exposed above water by the gradual isostatic rebound of the land after the ice melted. Sparse modern soils and muskeg are developed on this deposit.

2.23 Landscape

The flat bed of the Tyrrell Sea, which has been emerging from the waters of Hudson Bay for thousands of years, is still emerging. This process has produced an essentially planar surface with comparatively little relief except in the vicinity of raised shore lines (none of which cross the Onakawana lignite field) and to a slight extent along river valleys, where there is evidence of terracing. One such terrace at Onakawana, on the west bank of the Abitibi River, provides an obvious site for camp and plant installations.

The flat land surface at Onakawana is part of a larger plain that slopes gradually down to the shore of James Bay at a gradient averaging between two and three feet per mile.

2.24 Drainage

Three factors contribute to the poor drainage of this area. Firstly, the land surface is newly emergent from the sea and has had comparatively little time to develop an efficient drainage pattern. Secondly,

a factor intimately connected with the first, there is a general lack of any significant relief other than in the immediate vicinity of river banks, which would aid drainage. Both of these factors account for the generally parallel drainage schemes of the Abitibi, Moose and Onakawana rivers, as well as their shallow gradients which, in the case of the Abitibi, is 3.4 feet per mile.

A final determinant is the nature of the surficial deposits, which are compact, dense and of weak structure. The free passage of water is impeded. The surface expression of this is the predominantly swampy and moss covered ground between the rivers.

2.3 Soils

2.31 Descriptions and analysis

In many respects the soils of the region around Onakawana are remarkably alike. In general, the uppermost mineral deposits are stone-free, silty clay loams overlain by moderately well decomposed organic materials.

The organic deposit (muskeg) is of uniform thickness varying from 3 to 4 feet over the whole of the region. The only exception to this occurs within 300 feet of the Abitibi River where the organic materials are about 14 inches thick.

The organic deposit is black when wet, turning brown on drying and originates from woody materials. The fiber content varies from 32 to 36 per cent which, according to the Canada Soil Survey Committee (1970), places this in a group of organic soils called mesisols. Although inferior

to mineral soils as a growth medium these are considered to provide the best medium for plant growth of all organic soils mainly because water control is somewhat easier in them than in organic soils of more or less decomposition. The organic materials with pH of about 5.0 are much more acidic than the underlying mineral strata.

The mineral strata underlying the muskeg blanket vary in thickness and composition. Table 4 contains a summary of their physical, chemical and mineralogical characteristics. The most complete information about their thicknesses and extent can be gained from the records of the many drill holes. In general the muskeg is underlain by 5 to 7 feet of material which, although called marine clay by many people, is not really a clay in texture. Instead it varies in texture from silty clay loam to silt loam with clay contents of about 10 to 30 percent. Of greatest significance is the high silt content which may reach 80 per cent (Table 4). Silt-size particles are easily eroded by both wind and water and do not provide a good base for such structures as buildings and roads. Instead, frost boils are most difficult to control in silty materials that are saturated most of the time.

Boulder "clay" (glacial till) underlies the marine clay and, as in the case of the marine clays, the thickness of the deposit varies. Drill holes confirm thicknesses ranging between 12 and 110 feet. The boulder clays actually contain little clay (often less than 10%) compared to the amounts of sand and silt. The sand content is close to 50% and the silt content is commonly more than 30%. In spite of the numerous small stones and pebbles and the high sand content the boulder clay has been preconsolidated to an extremely high bulk density of about 2.20.

TABLE 4. Physical, Chemical and Mineralogical Analysis of the Marine Silts and Boulder Clay

Analysis		Marine Silts		Boulder "Clay"	
		Site			
		#1	#2		
(1)	pH	7.95	7.90	7.70	
(2)	Bulk density (g/cc)	-	1.70-1.80	2.15-2.22	
(3)	%CaCO ₃ equivalent	10 - 15	18 - 23	18 - 23	
(4)	Particle size (%)				
	1-2 mm	0.10	0.10	6.98	57.88*
	0.5 - 1.0	0.13	0.30	8.13	
Sand	0.25 - 0.5	0.10	0.46	8.40	
	0.10 - 0.25	0.22	1.70	19.69	
	0.05 - 0.10	5.10	7.40	14.65	
		5.65 9.96			
Silt	0.002-0.05	62.45	78.73	33.36	
Clay	>0.002 mm	31.90	11.31	8.76	
(5)	Mineralogy				
	<0.002 mm	dominate - vermiculite, mica, chlorite		dominate - mica; vermiculite; chlorite	
		minor - kaolin, quartz, feldspar, amphibole		minor - kaolin; interstratified mica-vermiculite; expanding minerals; quartz, feldspar, amphibole	

* This sample contains 13% of material >2mm.

Significantly, sand and gravel strata of variable thicknesses are present in lenses or layers at various depths. These layers may be of use for construction in the area.

The mineral materials have a much higher reaction than the muskeg. The marine deposits and the boulder "clays" are often weakly calcareous with a pH of about 7.7 to 7.9 and a CaCO_3 equivalent of 10-20%. Brief descriptions of the two major soil profiles follow:

#1 - Typical of most of the area

- O_1 - 0" to 10" pale brown, dominantly sphagnum, pH 4.5
- O_2 - 10" to 30" black when wet, brown when dry; moderately well decomposed (mesic); fiber content 34%; derived mainly from wood; pH 5.0.
- 11C - 30" - 34" dark gray silty clay loam; weak medium blocky structure; firm consistence when moist; hard when dry; stone-free; pH 6.6.
- 111C - 34"+ gray silt loam; weak prismatic structure; firm when moist, hard when dry; stone-free; pH 6.8.

Soil temperature at 2 feet is 7°C (taken in August).

#2 - Close to Abitibi River

- O_1 - 0 to 14" brown when dry, black when wet; moderately well decomposed (mesic) fiber content 31%; derived mainly from wood; pH 5.2.
- 11C - 14" to 18" pale brown sandy clay loam; sticky when moist, very hard when dry; weak prismatic structure; pH 6.4.
- 111C - 18" to 26" brown sandy clay; mottled; sticky when moist, very hard when dry; weak coarse blocky structure; stone-free; pH 6.7.

IVC - 26"† brown medium sand; loose; structureless; stone-free; pH 6.7.

The above soil type (#2) occurs close to the bank of the Abitibi River whereas profile #1 is typical of the remainder of the area. The sandy materials deposited along the river bank are underlain by the boulder "clay" at comparatively shallow depths.

2.32 Soil Temperatures

Low soil temperatures are a major cause of the slow growth in the region, as compared with other saturated soils. In order to gain some measure of soil temperatures simple thermometer readings were taken in August from different locations at a depth of 2 feet.

In the open areas of muskeg the temperatures recorded averaged 7°C whereas in wooded areas the average temperatures were 3.5°C. Temperatures of mineral materials ranged from 7 to 11°C depending on the drainage. The wet places had the lowest temperatures.

2.33 Site drainage

Soils are described as being well, imperfectly, or poorly drained. Well drained soils are those that are saturated less than 6 months of the year while poorly drained soils are wet or saturated for more than 9 months.

The entire region, with the exception of areas immediately adjacent to the rivers, are poorly drained and contain a high watertable throughout the year. This results primarily from a combination of low relief over the entire site and the impermeable nature of the materials

immediately underlying the organic deposits. The high bulk density of the marine silts (1.70 to 1.80 g/cc or 106-112/cubic foot) underlying the muskeg restricts downward movement of water and this results in a "perched" watertable forming above this layer. The low relief over much of the area inhibits lateral water movement within the organic deposits and consequently surface drainage is poor.

3.0 DEVELOPMENT PROBLEMS

3.1 Removal and stockpiling of the muskeg material

Because of poor site drainage (section 2.33) surface drainage of the entire area will be required. In addition it would be desirable to remove and stockpile the organic materials (muskeg) prior to development. This could be important for two reasons: firstly, organic materials cannot be used for backfilling purposes in mined-over areas because of their poor structural properties; and, secondly, if mixed with the surface soils it would contribute to post-site reclamation.

Care must be taken to prevent complete drying of the muskeg material during stockpiling. When dry it is difficult to again make it wet but, more importantly, it becomes highly combustible as well as being subject to wind erosion.

3.2 Erosion

The extensive slopes of stockpiled overburden and coal spoils associated with a strip mining operation of the Onakawana type are generally denuded of vegetation and are exposed to the full action of wind and rain. These erosive forces will cause a significant increase in sediment loads of

local stream systems unless precautions are taken. Work conducted in the United States has shown that sediment yield from the strip mined portions of a watershed may be 10 to 1,500 times that of undisturbed land.

Erosion takes place in two ways, as sheet erosion and as gullyng. Sheet erosion occurs with each rainfall because of displacement of soil particles by individual raindrops. It occurs over the entire landscape and the magnitude of its effect is proportional to the area exposed. Gullyng develops on slopes where water flow is concentrated into small channels or streams. Hazards associated with gullyng are usually greater as slope is increased.

Road construction, in particular, creates severe erosional problems as a result of disturbance and interference with natural drainage patterns. Most often, roads concentrate surface drainage at low points and this leads to gullyng.

Erosion at the Onakawana site can be expected to result from the following activities:

1. stockpiling overburden
2. road construction
3. stockpiling coal
4. pumping for control of mine drainage
5. surface drainage of the area
6. stream diversion

The marine silts will present the greatest problem in erosional control on the site. Silt textured soils and sediments are the materials that are the most susceptible to erosion and protective measures in the form of sediment ponds and revegetation will be required during

the initial stages of development where the muskeg overburden is removed resulting in surface exposure of the silt materials during stockpiling.

Also, erosion due to frost action during the spring months may be exceptionally high. As thawing occurs in the spring, a saturated zone of soil will form above the frost layer and this could lead to movement of soil downslope, especially on slopes exceeding 15-20%.

It cannot be overemphasized that the prime way of combating erosion is by keeping the area of disturbed, unvegetated land to a minimum. This can be accomplished by proper preplanning and by rapid reclamation. It is imperative that drainage control and sedimentation basins be installed prior to development and used until revegetation is complete.

Numerous methods for erosion control exist. These range from terracing stockpiled overburden and locating sediment ponds at appropriate locations to intercept sediment from pumping operations, (road construction, etc.) to revegetation programs.⁽³⁾

3.3 Slope stability

With the exception of the initial excavation it is assumed that the strip mining operation involves removal of the overburden and use of this material to backfill those areas in which mining has been completed. The overburden dump for the initial excavation site should be terraced and revegetation of the slopes should begin as soon as possible. Surface drainage of the terraces is also required. Stockpiling of overburden

(3) See Curtis (1971); Symposium Proceedings (1971).

directly on the muskeg materials or use of organic material in backfilling should be avoided if possible. Care should also be exercised in stockpiling the marine silts since such materials have a narrow plastic index and are particularly susceptible to slumping and sliding when saturated. The boulder "clay" should be suitable material for backfilling, road construction, etc. Table 4 indicates an absence of montmorillonite-type minerals in the marine silts and boulder "clay" so that slope stability problems or accelerated erosion problems associated with expanding clays will not arise. Moreover these materials contain the equivalent of 10% to 20% calcium carbonate (Table 4) which means that the clay is flocculated and less susceptible to dispersion and movement.

Problems with mass movement of materials downslope can be anticipated unless suitable precautions are taken. Precipitation data for Abitibi Canyon (Table 1) indicate that on the average the months of June, July, August and September receive over three inches of rainfall per month; this accounts for about one-half of the yearly precipitation. Substantial runoff can be expected during this period. Furthermore during the spring thaw a saturated zone of soil will form above the frost line. This will be subject to gravity flow on steep slopes.

Steep slopes should be avoided since they not only increase problems of slope stability but they are difficult to revegetate. The Alberta Environment Conservation Authority (1972) has suggested an absolute maximum of 27° (1:2) for spoil piles. Engineering tests will no doubt show that much steeper slopes are structurally stable, but such tests fail to

take into consideration the increased erosion and revegetation problems that will arise.

A report on the "Stability of Waste Embankments" prepared by a subcommittee of the Canadian Advisory Committee on Rock Mechanics (September 2, 1969) states:

"In view of the recent major failures of waste embankment, the recent increase in Canada of major mining developments, the lack of mining regulations in Canada and the limited background of mining engineers in stability-engineering the subcommittee believes that a potentially serious problem does exist and that urgent action is required to control the problem."

The stability of waste embankments is given treatment in a publication of the federal Department of Energy, Mines and Resources (1972), Tentative Design Guide for Mine Waste Embankments in Canada. These recommendations should be followed whenever spoil banks, waste embankments and sedimentation ponds are built.

3.4 Leachate problems

The Onakawana lignite are dark brown to black, woody and earthy deposits comprised of flattened stem material with an interstitial, fine grained detritus. It contains 50% or more of water. A major problem encountered in working these and other coals arises out of the common occurrence of pyrite (FeS_2) in them. When in contact with water and air pyrite weathers to produce ferric hydroxide and sulphuric acid. The ferric hydroxide ("yellow boy") discolours the surface waters of many coal mining districts. The acid produces a low pH in groundwaters and the soils through which they circulate, to the extent that the flora and fauna may be killed off. The Onakawana lignite was checked for pyrite and none was found. This is further confirmed by chemical analyses from the Department of Energy,

Mines and Resources, which show sulphur content to be very low. It seems safe to conclude that the lignite itself would not produce a significant acidifying effect on the environment. This much cannot be said of the associated Cretaceous clays since samples were not provided for study. It is conceivable that they may be pyritiferous as, in fact, shale beds in the underlying Devonian are known to be. It would therefore be a logical precaution to investigate the possibility of pyrite occurring in those Cretaceous beds that will be stripped with the lignite, and thereby exposed to oxidation at the surface.

Two water samples were brought back to the University of Guelph for analysis. It is noteworthy that the water from the lower lignite seam was less acid than the muskeg water.

The analysis of water from lignite in Table 5 gives concentrations of common plant nutrients released into the water. The alkalis and magnesium are particularly high in comparison to their values in muskeg water and if the waters were impounded in settling ponds, the nutrients might stimulate algal growth.

If it is assumed that the coal is being stockpiled at Onakawana the leachate could be handled in a number of ways. One of these would involve the use of the calcareous boulder "clay" as a base to the stockpiles thus allowing the leachate to percolate down through the calcareous materials. The free CaCO_3 would neutralize any acid present in the leachate and, in addition, flocculate out any colloidal-size organic material in suspension.

TABLE 5. Analyses of two samples of water from the Onakawana area.

	A. Muskeg water	B. Sample from lower lignite bed.
pH	6.3	7.2
K	.8	6.5
Na	.2	18.2
Ca	22.1	16.6
Mg	23.5	109.6
Fe	1.0	.2
N	.0	.8
P	.1	.3

Trace elements in ppm (mg/litre)

Decomposed organic matter from the stockpiled muskeg deposits will also eventually reach the drainage ways via erosion. Hence the importance of preplanning cannot be overemphasized. Prior to the company beginning work in the area catchment ponds should be located so as to intercept all run-off that would enter the streams from the construction site. This includes run-off arising from surface drainage, pumping operations at the mine site and natural run-off. The catchment ponds should be designed to allow the settling of the heavy silts and sand.

2.5 Pumping of mine or drainage waters

Pumping can be expected to cause two major problems; erosion and deterioration of water quality. The problems arising from erosion, which evidences itself in the siltation of stream beds, etc., can be overcome by sediment ponds. However, there is some cause for concern that pumping of water in contact with the coal could lead to the discoloration of water in streams, a consequence of the persistence of finely divided, suspended coal particles.

To test this 50 gram samples of coal were shaken in a litre of de-ionized water (5% suspension) for about 12 hours and allowed to stand undisturbed. The supernatant in the sedimentation cylinders remained extremely cloudy and no apparent settling of particles or clearing of the suspension had occurred after two weeks. Further, this material does not settle out of suspension by centrifugation of 1200 X gravity. It can, however, be flocculated out of suspension by using any common electrolyte such as calcium chloride, sodium chloride, etc. The addition of some sort of flocculating agent in the sedimentation ponds would prevent such material from reaching the streams and rivers.

Because of the pH level (6.0-7.0) and CaCO_3 content of the sediments in the area, the solubilities of inorganic ions such as iron and manganese are negligible and, if released, would be oxidized and precipitated rapidly. The concentrations of these elements are such that no iron or manganese problem is anticipated.

3.6 Heavy metal contamination

Heavy metals constitute a further environmental hazard that might be encountered. Coals and their seat earths (fireclay in this case) are to some extent notorious as sources of high trace element concentrations. Mercury, zinc, cadmium, germanium and selenium, for example, may be present in abnormal amounts. Some circumstantial evidence that this possibility is worth investigating is provided by Dr. Jordan of the University of Guelph whose preliminary analyses suggest that fish caught in the Abitibi River below Onakawana may have unusually high selenium in their tissues.⁽⁴⁾ This may or may not be attributable to Cretaceous rocks.

A more serious chance of atmospheric contamination could arise at the power station where the lignite is to be burned. If the Onakawana lignite does contain notable amounts of heavy metals, smoke and fly-ash might carry the contamination over a wide area. Again, this suggests the need for more geochemical information about the deposit.

3.7 Disposal of ash materials

Methods used for disposal of the ash materials will depend on the plant operations. If the ash material is disposed of in the form of a slurry, holding ponds will be required to prevent thermal as well as sediment

(4) His full report will be available to the Ministry of the Environment by December, 1972.

pollution of the streams. Indeed, some operations recycle the cooled water from these ponds.

Use of the ash will depend on its physical and chemical properties. On one hand it may be left and allowed to eventually fill the holding ponds or, alternatively, if it is coarse textured (greater than 2mm), sintered material, it could be incorporated and mixed with the surface soils to provide a porous, well structured medium for revegetation purposes.

Further work on the properties of the ash and ratio of soil-ash mixtures will be required if the latter alternative is entertained.

3.8 Site reclamation

The mineral materials taken from the pit should be piled at least 5 feet above the present surrounding land surface to provide some relief to the area for site drainage following reclamation. It is realized that this will result in a lack of material to refill part of the mined over area but an after use plan could include the establishment of an artificial lake. All of the mined area should be partially levelled. Agricultural experience has shown that a 6% slope has virtually no erosion, thus allowing the most rapid possible revegetation. As the slope increases from 6% to 27% the amount of erosion increases. Further investigation to determine the practical limits as to the optimum degree of slope at Onakawana will have to be undertaken.

The surface three to five feet of soil should consist of the interglacial sand and gravels or the boulder "clay" mixed with muskeg material.

The former may be preferred to the latter since the boulder "clay" has been preconsolidated to a high bulk density (Table 4) and may not break down easily. Such mixing will improve soil structure and soil moisture relationships and improve plant growth. Although no research has been done concerning the proper proportions of organic to mineral materials perhaps 6 to 10 per cent of organic matter in the surface levels is about the right amount.

The surface of the soil should not be compacted prior to seeding or revegetation; a loose friable surface will ensure good stand-establishment.

It appears that the overburden will be favorable for tree growth. Lime will not be needed because the spoil is calcareous. Fertility levels are sufficiently high for tree growth although an initial application of nitrogen fertilizer may be beneficial. Alternatively, use of legumes as a nurse crop may prove sufficient.

Revegetation of the area should consist of two stages:

- (i) quick establishment of a ground cover of grasses or legumes to control erosion and act as a nurse crop for secondary vegetation;
- (ii) a revegetation oriented toward establishing those species that best meet the land use objectives of the reclamation plan.

The first phases should begin once suitable areas are ready; the second phase of revegetation will take several years for completion.

Spoil acidity is usually considered the single most important factor affecting plant survival and growth. However, in the present situation, it is unlikely that acid problems will arise due to the low sulphur content of the coal and the high pH of the water associated with the coal. (Schessler and Droege, 1965).

A medium for plant growth can be left on site that is much better than presently exists. Poor vegetation growth in the area obviously reflects climatic conditions to a degree but, more importantly, it arises from the continually saturated water conditions of the organic soils which prevail throughout the area. Plant growth will be improved by drainage and by providing a good mineral soil as the rooting medium. This will also increase the number of tree species available for the revegetation program, e.g. poplars, pines, etc.

It is important not to directly relate the success of revegetation programs on strip mined areas in Saskatchewan and Alberta to the prospects on the Onakawana site: although the winter climates of the prairies may be as harsh or harsher than at Onakawana, their summer conditions are much more conducive to plant growth. Comparison of degree-days, which is a much better indicator of growth conditions than length of growing season, temperature, etc. for the different sites give an indication of this (Chapman and Brown, 1966):

- (i) Estevan, Saskatchewan: 2,500 to 3,000 degree-days.
- (ii) Edmonton, Alberta: 2,000 to 2,250 degree-days.
- (iii) Onakawana (calculated and extrapolated from Table 1):
1,700 to 1,850 degree-days.

3.9 Disposal of sewage effluent

With the exception of those areas immediately adjacent to rivers and streams the entire area is covered by two to five feet of muskeg overlaying marine silts. The muskeg is poorly drained and contains a watertable at or within 12 inches of the soil surface throughout the year. Consequently, these soils are not suitable for disposal of sewage effluent by septic tank or spray irrigation. Approximately five to seven feet of well drained soil are required by Ontario Ministry of Health regulations. Materials exist in the overburden that could be used to prepare a septic tank field; the boulder clays are considered preferable to the silts for this purpose.

4.0 CONCLUSIONS

1. Due to the pH of the coal-leachate and of water associated with the coal beds, it is not anticipated that acid leachate will be a problem in a strip mining operation of coal at Onakawana. Furthermore, the marine silts and boulder "clays" which are the major sediments overlying the coal are calcareous (i.e. CaCO_3) and these will serve to neutralize any acid materials. The Cretaceous fireclays, however, should be checked for their content of pyrite or heavy metals.

2. Surface drainage of the area will be required prior to development, as well as, presumably, stockpiling of the surficial organic materials. This will lead to increased erosion on the site which can be controlled by proper preplanning and installation of sedimentation ponds. An initial plan for post-drainage of the area is therefore required.

3. Erosion will increase as a result of the strip mining operations but its effects can be minimized or reduced to negligible levels by such erosion-control measures as sedimentation ponds and revegetation programs. The catchment ponds should be inspected at regular intervals for performance.

Roads should be planned and constructed so as to minimize the effect of road construction on stream systems; construction on steep slopes must be held to the essential minimum.

4. Problems of slope stability may be minimized by reducing the effective slope of spoil piles and by initiating as rapidly as possible revegetation of the slopes. A problem that could arise on steep slopes is mass slope movement due to saturated moisture conditions which may prevail in the early spring and summer periods.

Care should be taken in stockpiling the marine silt materials since they are particularly susceptible to slumping under saturated conditions.

To ensure that the waste slopes can be revegetated satisfactorily the grade slopes should be kept to a minimum, the tops of terraces

should be graded inward to discourage surface runoff and, if possible, the tops of terraces should incorporate the recommended topsoil mixture in the final grading.⁽⁵⁾

5. Water discoloration may arise because of pumping on the mine site. Sediment holding ponds will not overcome this problem; nevertheless the finely divided coal particles can be flocculated out of suspension by the addition of an electrolyte.
6. It is emphasized that the key to success of all control measures is preplanning. With proper planning, many deleterious effects can be prevented, and others remedied with much less expenditure of time, effort and capital. Further, if the costs of environmental repair are estimated in the feasibility study they are budgeted as part of the cost of mine development and operation and do not subsequently arise as an unbudgeted cost. Before the company begins work in the area it should construct catchment ponds in small streams downhill from the work and should so locate them that they intercept any surface runoff from denuded sites.
7. Site conditions that will improve the ability to grow plants, relative to conditions now existing at Onakawana can be developed following the strip mining operation. These include contour grading to provide the area with some surface drainage and mixing of the muskeg or other material with the mineral soil to provide a suitable rooting medium.

(5) Further details of design guidelines for waste embankments appear in Technical Bulletin #145 (1972), available from the Department of Energy, Mines and Resources, Ottawa.

8. Lignite deposits have been mined in Alberta and Saskatchewan for a considerable period of time. Close communication should be established with these Provinces at the Ministry level to draw on their body of experience.⁽⁶⁾

(6) Pertinent information is available in such publications as the Proceedings of the Public Hearings on "The Impact of the Environment of Surface Mining in Alberta" published by the Environmental Conservation Authority of Alberta (1972).

5.0 BIBLIOGRAPHY

1. Alberta Environment Conservation Authority. 1972. The impact of the environment of surface mining in Alberta. Proc. Public Hearings, Part I and II. 1060 pp. Environment Conservation Authority, Edmonton.
2. Canada Department of Energy, Mines and Resources. 1972. Tentative design guide for mine waste embankments in Canada. Tech. Bull. #145.
3. Canada Soil Survey Committee. 1970. The System of Soil Classification for Canada. Canada Department of Agriculture. Ottawa.
4. Canada Department of Transport, Meteorological Branch. 1967. "Temperature and Precipitation Tables for Ontario". Vol. IV.
5. Chapman, L.J. and D.M. Brown. 1966. The Climates of Canada for Agriculture. Canada Land Inventory. Report #3.
6. Chapman, L.J. and Thomas, M.K. 1968. "The Climate of Northern Ontario", Climatological Studies, No. 6, Toronto.
7. Curtis, W.R. 1971. Terraces reduce runoff and erosion on surface-mine benches. J. Soil & Water Conserv. 26(5):198-199.
8. Dyer, W.S. and A.R. Crozier. 1933. Lignite and refractory clay deposits of the Onakawana lignite field. O.D.M. Ann. Rept. 52 part 3, 46-78.
9. Lee, H.A. 1968. Quaternary Geology, in Science, History and Hudson Bay. V. 2, ch. 9, 503-543. Queen's Printer, Ottawa.
10. Martison, N.W. 1952. Petroleum Possibilities of the James Bay Lowland Area. O.D.M. Ann. Rept. 61 part 6, 1-58. (Contains a full bibliography of previous work).
11. Sanford, B.V. and A.W. Norris. 1970. The Hudson Platform in Geology and Economic Minerals of Canada. G.S.C. Econ. Geol. Rept. #1, ch. 4, 137-145. Queen's Printer, Ottawa.
12. Schessler, T.E. & R.F. Droege. 1965. Strip-mine reclamation: A digest. J. Soil & Water Conserv. 20(1):17-20.
13. Symposium Proceedings. 1971. Rehabilitation of drastically disturbed surface mined lands. Georgia Surface Mined Land Use Board. Georgia.
14. Terasmae, J. and O.L. Hughes. 1960. A polynological and geological study of Pleistocene deposits in the James Bay Lowlands, Ontario. G.S.C. Bull., 62, 15 p.

Appendix A

ONAKAWANA PROJECT

(Proposed development of lignite coal deposits)

The proposed development of the lignite deposits south of James Bay involves several areas of concern for which preliminary answers are required. It is believed that the mining operation would, in general terms, follow such steps as: (a) removal of the overburden including organic and clay deposits, (b) stockpiling the overburden, (c) removal of lignite by open pit mining, (d) combustion of the lignite, and (e) handling and ultimate disposal of by-products such as stack effluents (gaseous and particulates), non-combustible and non-usable residues, and warm water.

The undersigned faculty members of the University of Guelph were approached by Task Force Onakawana and requested to outline their concept of the management of the Onakawana project area during and following mining operations. The faculty members are soil and land use specialists. Accordingly, the comments, proposals and recommendations deal primarily with soil, land use, vegetation and water management aspects.

Objectives

It is recognized that an operation of this magnitude and nature will significantly affect the local environment -- wildlife, vegetation, natural drainage and the overall landscape. We do not accept the suggestion that the disruptions are of catastrophic proportions and that nothing can be done

to develop and maintain an appropriate environment during and after the mining operations. The objectives in terms of soil, water and vegetation management should be:

- (1) to manipulate and handle the overburden in such a fashion that the materials are used to create elevated sites possessing a better drainage and better prospects for vegetation and wildlife than heretofore existed.
- (2) to use the native materials, primarily overburden, to create lakes and lagoons of a permanent nature that in the mining operation, are useful as sedimentation lagoons and for temperature equalization of waste water.
- (3) to create an area during operations and after operations that is essentially stabilized, that is revegetated and is so managed that erosion, runoff and sedimentation are controlled at acceptable levels.

We submit that the undersigned faculty possess the expertise to conduct preliminary surveys of the site and to make meaningful and practical recommendations for the management of the site with the foregoing objectives in mind.

Our submission is in three parts:

- A. Inventory data -- what information is required and how obtained.
- B. Interpretations and recommendations -- how the inventory data are used to prepare guidelines for the management of the area.
- C. Budget -- includes travel expenses, laboratory analyses, photo interpretations, report preparation and professional fees.

Inventory Data

The following inventory data will be acquired from on-site inspections, air photo interpretations and laboratory analyses:

1. Detailed characterization (physical and chemical) of soils and characterization of surficial geology and land forms.
2. Natural drainage patterns and their relationship to soil and surficial geology and feasible drainage patterns and problems during and after development.
3. The extent and nature of organic deposits.
4. A complete characterization of the sub-surface clays and the interrelationships to stability, subsidence, slippage and erodibility.

Interpretations and Recommendations

Based on the inventory data and climatic records available, interpretations and recommendations will be provided in the following areas:

1. Location and extent of suitable granular materials for town-sites, roads, etc.
2. Suitability of various soils for foundation support and disposal of sewage effluent.
3. Erosion and siltation problems arising from development and preventative measures, to include problems arising from the mining operation itself, road construction, townsite development, etc.
4. Disposal of waste products (solid wastes as well as slurries) from ignition of the coal: e.g., incorporation of ash materials with the clay sub-soil to provide a suitable medium for revegetation.

5. Slope stability problems arising from stockpiling clays: to provide answers to this problem, data is required on the swelling characteristics of the clays, their water holding capacity and particle size distribution and whether they are marine or non-marine in origin.
6. Problems associated with stockpiling clays on organic terrain and anticipated effects of frost action.
7. Problems associated with disposal of water: this is partially related to 3 and includes those problems associated with pumping water from the mining pit operation and disposal of warm water from the generating station.
8. Leachate problems arising from stockpiling coal: it is assumed that we will be supplied with analysis of the coal.
9. Soil management problems concerned with revegetating mine spoils.
10. Future on-site drainage problems.
11. Relationship of climatic factors to the location of the generating plant and as well to suitable types of vegetation for revegetating the area.
12. Alternative uses for the sub-surface clays, e.g. fireclays.

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